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Implementing Project-Based Learning in Grade 3 Mathematics: A Kurikulum Merdeka Case Study in Indonesia

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ABSTRACT

This qualitative descriptive study examines how Project-Based Learning (PjBL) was planned and enacted in Grade 3 mathematics at SD 1 Pokoh Kidul within the Kurikulum Merdeka framework and explores its effects on student learning as well as implementation challenges. Data came from semi-structured interviews, non-participant classroom observations, and document analysis of lesson plans, worksheets, and assessment rubrics. A thematic analysis was conducted, with triangulation across data sources and member checking to support trustworthiness. Findings indicate that PjBL embedded mathematics in authentic, real-world contexts and enhanced problem-solving, critical thinking, and conceptual understanding. Non-cognitive gains included stronger collaboration, communication, self-regulation, and confidence. Topic-specific projects such as designing simple structures for geometry and operating a "classroom restaurant" for fractions helped make abstract ideas tangible and engaging. Integration of educational technology (e.g., augmented-reality applications and interactive simulations) further supported visualization and participation. Differentiated instruction and scaffolding enabled students with diverse learning needs to contribute meaningfully. Key challenges concerned time management, equitable participation, resource constraints, and designing assessments that capture both process and product. The study recommends targeted professional development, interdisciplinary project design, and alignment with sustainability education principles to strengthen PjBL integration. Overall, the findings suggest that PjBL is a feasible and promising approach for primary mathematics in Indonesia, advancing academic outcomes alongside essential twenty-first-century competencies.

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1. Introduction

Teaching mathematics to elementary students is challenging because many concepts are abstract and exceed the typical developmental readiness of children at this stage. Developmental perspectives, including Piaget, suggest limits to abstract reasoning in early grades. Consequently, conventional instruction that prioritizes deduction, symbol manipulation, and rote memorization often proves inadequate (Chin et al., 2022; Rohmah & Jupri, 2024; Saputro, 2021). To close the gap between pedagogy and learner readiness, approaches that provide concrete, hands-on experiences are recommended. Realistic Mathematics Education (RME) offers one such pathway by situating problems in meaningful, real-life contexts to make abstraction accessible (Negara et al., 2021; Rudyanto & Destia, 2023).

In Indonesia, the Kurikulum Merdeka creates a supportive policy environment for these innovations. The curriculum emphasizes critical thinking, creativity, and contextual understanding through problem-based and project-oriented learning that connects mathematics to authentic situations (Halimah & Kurniawati, 2022; Rauzah & Vitoria, 2023). Integration of educational technology such as augmented reality applications, interactive simulations, and multimedia materials has been shown to enhance engagement and deepen understanding, contributing to more dynamic and participatory classrooms (Apriza et al., 2024; Aswani et al., 2024; Pahmi et al., 2023)

Within this landscape, Project-Based Learning (PjBL) aligns closely with constructivist theories by positioning students as active agents who work in extended, collaborative projects that mirror real-world challenges (Hussein et al., 2024; Siswadi et al., 2024; Yanti et al., 2024). Through investigation, design, and production of tangible outcomes, students build conceptual understanding and practice higher-order thinking (Baharullah et al., 2022; Shoimah & Fatoni, 2023; Zuhri et al., 2024). This stands in contrast to teacher-centered approaches that often limit exploration and reduce learning to passive information intake.

Comparative evidence indicates that PjBL can outperform conventional methods in primary mathematics. Rather than emphasizing procedural fluency in isolation, PjBL integrates conceptual understanding, procedures, and problem solving in meaningful contexts (Maroš et al., 2021; Rijken & Fraser, 2023). Students taught through PjBL typically show higher motivation, stronger knowledge retention, and better transfer to novel situations (Halimah & Kurniawati, 2022; Wulandari & Nawangsari, 2024).

A distinctive strength of PjBL is its embedding of 21st-century competencies critical thinking, collaboration, and creativity within the learning process. Students apply mathematical reasoning to authentic problems, negotiate ideas with peers, and present findings in varied formats (Halimah & Kurniawati, 2022; Yanti et al., 2024). The collaborative dimension supports cognitive gains while cultivating interpersonal and communication skills valued in contemporary education and work (Hayati et al., 2022; Zebua et al., 2022).

Contextualized, problem-based tasks also enhance motivation and comprehension. When learners meet mathematics through lived experiences budgeting an event, constructing models, or measuring local features the subject becomes relevant and purposeful (Fatkurochman et al., 2024; Rasmini & Antara, 2023). Embedding mathematics in authentic contexts strengthens mathematical communication and problem-solving (Amita, 2023; Gazali & Atsnan, 2022; Inganah et al., 2023) and fosters deeper conceptual mastery and long-term retention (Rusmini et al., 2024; Sholeha et al., 2022).

Despite these advantages, successful PjBL implementation requires more than a methodological shift. It must align with curriculum standards, be supported by teacher preparation, and be resourced adequately for project work. While the flexibility of Kurikulum Merdeka suits PjBL integration, variation in student ability, time constraints, and the need for differentiated instruction demand careful planning and ongoing professional development.

In this context, the present study investigates PjBL implementation in Grade 3 mathematics at SD 1 Pokoh Kidul. We examine teachers' understanding and application of PjBL principles, the alignment of practices with Kurikulum Merdeka, and the perceived effects on student engagement, motivation, and learning. This study contributes a context-specific account of PjBL at the primary level in Indonesia and offers practical insights for improving mathematics instruction in similar settings.

This study addresses three questions: how Grade 3 teachers at SD 1 Pokoh Kidul design and enact PjBL in mathematics in alignment with Kurikulum Merdeka; in what ways PjBL influences students' engagement and conceptual understanding particularly in geometry and fractions; and what implementation challenges arise (e.g., time, equitable participation, assessment) and how process- and product-oriented assessments are used to address them.

2. Method

This study employed a qualitative descriptive design to examine how Project-Based Learning (PjBL) was implemented in Grade 3 mathematics at SD 1 Pokoh Kidul, with attention to teachers' understanding, instructional practices, and student engagement. A descriptive qualitative approach was appropriate for producing a detailed, context-rich account of classroom phenomena as they naturally occurred, without manipulating variables, and for foregrounding participants' experiences, perspectives, and meanings (Salarvand et al., 2023; Sezer & Can, 2022).

2.1 Research design and rationale

We followed an exploratory–descriptive framework that enabled in-depth analysis of pedagogical approaches and the learning dynamics fostered by PjBL. The design integrated multiple data sources so that instructional strategies and student responses could be examined holistically and compared across evidence streams.

2.2 Setting and participants

The study took place at SD 1 Pokoh Kidul, a public elementary school implementing the Kurikulum Merdeka. Primary participants were Grade 3 teachers responsible for mathematics instruction and directly involved in PjBL activities. To triangulate teacher reports, we also observed student interactions and examined student work products generated during projects. Participants were selected purposively on the basis of first-hand engagement with PjBL so that the sample reflected rich, relevant experience with the approach.

2.3 Data collection.

We used three complementary techniques semi-structured interviews, non-participant classroom observations, and document analysis supplemented by reflective field notes. Semi-structured interviews were conducted with the Grade 3 homeroom teacher who led mathematics instruction. The interview protocol explored the teacher's understanding of PjBL principles, lesson-planning strategies, perceived benefits for students, and challenges encountered. The semi-structured format ensured consistent thematic coverage while allowing participants to elaborate on salient experiences and provide concrete examples (Salarvand et al., 2023). Non-participant observations were carried out during mathematics lessons to capture authentic teaching and learning processes. Observation focused on the stages of PjBL implementation topic introduction, group collaboration, project development, presentation, and reflection and on student-engagement indicators such as participation, collaboration, and problem-solving behaviors (Gumartifa et al., 2023). Observers recorded descriptive and analytic notes using an observation guide aligned with the study objectives to support systematic, comparable accounts of classroom activity. Document analysis targeted instructional artefacts, including lesson plans (Rencana Pelaksanaan Pembelajaran, RPP), student worksheets, and assessment rubrics, to evaluate alignment with PjBL methodologies and the Kurikulum Merdeka framework (Cutrera, 2023). Student project outputs were also reviewed for evidence of conceptual understanding, creativity, and real-world application. Throughout fieldwork, the researcher maintained reflective journals to document contextual details, emerging insights, and methodological decisions; these notes supported iterative sense-making during analysis (Deniz & İzci, 2023).

2.4 Data analysis

We applied thematic analysis to all sources, following the steps of familiarization, coding, theme generation, review, definition, and reporting. This analytic approach offered flexibility for identifying

patterns and relationships in qualitative data and for tracing recurring themes related to PjBL implementation, student engagement, and learning outcomes (Salarvand et al., 2023). Codes were developed inductively from the data corpus and iteratively refined as new evidence accumulated. Themes were then mapped across interviews, observations, and documents to examine convergence and divergence of evidence and to construct coherent accounts of practice.

2.5 *Triangulation and use of quotations*

Methodological triangulation was achieved by comparing interview accounts with classroom observations and documentary evidence, thereby strengthening the credibility and validity of interpretations. Where appropriate, direct quotations from participants are included in the Results to illustrate key themes and preserve the authenticity of teacher and student voices.

2.6 Trustworthiness

To enhance trustworthiness, we implemented member checking by inviting participants to review and verify preliminary interpretations; conducted peer debriefing with fellow researchers to challenge assumptions and refine themes; and maintained an audit trail of instruments, field notes, coding memos, and analytic decisions. Credibility was supported through prolonged engagement in the field; transferability through thick description of the school context and instructional routines; and dependability through systematic documentation of procedures and decision points.

2.7 Ethical considerations

The research protocol received approval from the relevant institutional body. Informed consent was obtained from all participants prior to data collection. Pseudonyms are used in all records and reporting to protect identities, participation was voluntary, and participants could withdraw at any time without consequence. All data were stored securely in accordance with institutional guidelines.

Overall, the methodological choices an exploratory descriptive design, purposive sampling of directly involved teachers, multi-method data collection, and rigorous thematic analysis were intended to produce a credible, replicable account of PjBL as enacted in a Grade 3 mathematics classroom under the Kurikulum Merdeka policy framework while preserving the voices and contexts of those most closely engaged in the work (Cutrera, 2023; Deniz & İzci, 2023; Gumartifa et al., 2023; Salarvand et al., 2023; Sezer & Can, 2022).

3. Result

This section presents the findings on the implementation of Project-Based Learning (PjBL) in Grade 3 mathematics at SD 1 Pokoh Kidul. Analysis of interviews, observations, and documents yielded three overarching themes: (1) instructional design and adaptation of PjBL for mathematics topics; (2) student engagement, collaboration, and learning outcomes; and (3) challenges and assessment practices in PjBL.

3.1 Implementation of PjBL in Mathematics Instruction

Teachers integrated PjBL into mathematics through structured lesson designs that supported inquiry-based, student-centred learning. They reported adapting elements of the ADDIE cycle Analysis, Design, Development, Implementation, and Evaluation phases of the 5E model Engage, Explore, Explain, Elaborate, and Evaluate to organise activities, materials, and reflections (Wiratman et al., 2023). During the analysis stage, teachers identified competency targets and aligned them with Kurikulum Merdeka learning outcomes. Design and development emphasised contextual problems to spark curiosity and ensure relevance. Implementation centred on collaborative group work and hands-on activity leading to tangible products, while evaluation combined formative checks with summative judgements to capture both the process and the quality of outputs.

Adaptations were tailored to specific mathematical topics to foreground real-world application. In geometry, students designed blueprints for simple structures (e.g., miniature houses) that required recognition of shapes and reasoning with perimeter, area, and volume (Gao & Zhang, 2023). In fractions, a “classroom restaurant” project engaged learners in composing menus and recipes with

fractional quantities so that measurement and proportional reasoning were practised in a familiar context (Rostikawati et al., 2024). Digital and interactive tools supplemented these projects. For geometry, augmented-reality applications helped students visualise 3D shapes and their components; for fractions, interactive games and simulations supported practice and immediate feedback, aligning technology use with collaborative learning routines (Apriza et al., 2024).

3.2 Student Engagement, Collaboration, and Learning Outcomes

Across observed lessons, PjBL was associated with more frequent collaborative talk and visible coordination among group members. Students discussed alternative strategies, negotiated task roles, and co-authored products, behaviours that teachers linked to increased ownership of learning and improved confidence (Oktaviani et al., 2023; Wahyudiati & Qurniati, 2022). Participants described how shared responsibility for completing a product motivated meaningful contributions, while peer interaction enabled mutual support during problem solving (Firdausi et al., 2023; Hikmah et al., 2023). Observational field notes documented a shift from passive reception to active engagement, with more learners posing questions, offering explanations, and participating in whole-class discussions.

The contextual nature of projects appeared to make mathematical ideas more accessible and relevant. In geometry, linking shapes and measurement to the practical task of designing usable spaces helped students articulate relationships among dimensions and justify calculations. In the fraction project, the act of "serving" dishes with precise quantities reinforced proportional reasoning in a relatable scenario (Chang et al., 2024; Darmawan et al., 2023). Teachers reported improved problem-solving performance when tasks required transfer of concepts to novel situations for example, budgeting for a class event, which integrated arithmetic, measurement, and estimation (Chistyakov et al., 2023). They also noted stronger retention of core ideas when knowledge had been constructed through application rather than memorised procedures (Hikmah et al., 2023).

3.3 Challenges in PjBL Implementation and Assessment Practices

Despite the benefits, several constraints complicated routine use of PjBL. Time management was the most frequently cited issue: project tasks often exceeded standard lesson periods, and teachers had to reconcile open-ended activity with pacing and coverage expectations. Ensuring equitable participation in heterogeneous groups also required close monitoring and targeted scaffolds for learners with different readiness levels (Anwar et al., 2024; Uyen et al., 2023). Resource management presented additional hurdles, including the effort needed to prepare materials and occasional limitations in technology infrastructure. Teachers expressed a need for more sustained professional development on PjBL design, facilitation, and classroom management to fully leverage the approach (Sudarsono et al., 2022).

Assessment practices reflected a deliberate balance between process and product. Process-oriented assessment drew on learning journals, structured group discussions, and peer evaluations to document collaboration, problem-solving approaches, and individual contributions over time (Anwar et al., 2024). Product-oriented assessment employed analytic rubrics to judge creativity, mathematical accuracy, and the clarity of final presentations (Sudarsono et al., 2022). Teachers emphasised that attending to both dimensions was critical for capturing the breadth of student learning in PjBL contexts: process evidence recognised effort, participation, and strategy development, while product evidence provided an anchor for evaluating conceptual accuracy and application in the culminating artefacts.

4. Discussion

The findings reaffirm that Project-Based Learning (PjBL) functions as a robust pedagogical approach in primary mathematics classrooms by supporting gains in both cognitive and non-cognitive domains. In this context, PjBL situated mathematical ideas in authentic tasks, encouraged collaborative inquiry, and provided repeated opportunities for students to make and justify decisions during project

work. The discussion below interprets these results in relation to the literature and to the goals of the Kurikulum Merdeka, and it outlines implications for practice, assessment, and sustainable adoption.

4.1 Cognitive skill development through PjBL

PjBL offered authentic contexts for problem solving that prompted students to apply mathematical reasoning to concrete goals. This pattern is consistent with earlier research indicating that PjBL enhances critical thinking, analytic judgment, and creative solution generation (Yanti et al., 2024). In the present study, geometry and fraction projects required learners to integrate conceptual knowledge with practical applications for instance, designing structures, calculating dimensions, and adjusting measurements thereby exercising cognitive flexibility and strengthening conceptual–procedural links (Rehman et al., 2023). The collaborative format also required students to articulate and defend their strategies to peers, a practice that deepened understanding and aligned with social-constructivist perspectives on learning. In sum, PjBL replaced rote recall with inquiry-driven activity that supported longer-term retention of core ideas.

4.2 Non-cognitive skill development

Beyond cognition, students developed collaboration, communication, and self-regulation competencies highlighted in classroom observations and aligned with the aims of the Kurikulum Merdeka. Learners divided responsibilities, coordinated timelines, and monitored collective progress, building skills that matter for academic and everyday contexts (Rahayu & Putri, 2021). The iterative nature of projects also nurtured persistence and adaptability as groups revised plans in response to challenges. Public presentation of products further boosted confidence and oral communication, contributing to an engaged, participatory classroom culture.

4.3 Adapting PjBL for diverse learning needs

While overall benefits were evident, inclusive implementation remained a central concern, particularly for students with mathematical learning difficulties. Differentiated instruction was essential for tailoring tasks to varied ability levels (May & Hoe, 2022). In practice, teachers used visual aids and manipulatives to concretise abstract ideas; integrated technology-enhanced tools such as GeoGebra to model shapes and transformations dynamically (Lainufar et al., 2021); and provided structured scaffolding guided steps, checklists, and periodic feedback to support less confident learners (Kızılelma et al., 2023). Thoughtful grouping enabled peer tutoring in which more proficient students supported classmates who needed additional guidance. These moves promoted equitable participation and ensured that all students could contribute meaningfully to the project workflow.

4.4 Sustainable integration of PjBL into Kurikulum Merdeka

Scaling PjBL within the Kurikulum Merdeka requires a systemic orientation. One promising pathway is alignment with Education for Sustainable Development (ESD), whereby mathematics projects address issues such as environmental conservation, community development, and resource management (Wang et al., 2022). Such projects retain disciplinary rigor while cultivating social responsibility. Professional development is pivotal: teacher learning opportunities should explicitly target PjBL design, classroom facilitation, and assessment that captures both content mastery and broader competencies (Rantanen et al., 2025). Progress also depends on collaboration among educators, policymakers, and local communities to share practices, co-develop resources, and support iterative innovation in lesson design (Park et al., 2024). Interdisciplinary designs can amplify these benefits; for example, combining mathematics with science in environmental monitoring or integrating art into geometry design tasks encourages holistic learning and creative problem solving (Biase et al., 2021).

4.5 Assessment in PjBL contexts

Effective assessment is central to PjBL, especially in interdisciplinary or sustainability-focused projects. A balanced framework proved most useful in this study. Formative assessments learning journals, ongoing observations, and peer reviews tracked progress and documented collaboration, engagement, and evolving strategies (Zabidi & Jamaludin, 2024). Summative assessments employed

clear analytic rubrics to evaluate the quality of the final product, mathematical accuracy, creativity, and alignment with project goals, thereby enhancing transparency and fairness (Birdman et al., 2021). Considering both process and product aligned with the Kurikulum Merdeka objective to foster holistic outcomes that encompass knowledge, skills, and attitudes, and it provided teachers with actionable evidence to guide feedback and next steps.

4.6 Implications

Taken together, the results indicate that thoughtfully adapted PjBL can strengthen primary mathematics learning in Indonesian schools by cultivating cognitive agility alongside collaborative competencies needed for real-world problem solving. Realising this potential, however, depends on addressing practical constraints time, resources, and equitable participation through targeted professional development, provision of materials and technology, and supportive school-level policies. Sustainable adoption further requires continued alignment with national education goals, interdisciplinary innovation, and a firm commitment to inclusive practices. These conditions would enable PjBL to function not as an isolated method but as part of a coherent instructional system under the Kurikulum Merdeka.

5. Conclusion

This study shows that Project-Based Learning (PjBL) can be designed and enacted in Grade 3 mathematics in ways that align with the aims and flexibility of the Kurikulum Merdeka. Teachers planned projects with clear competency targets and structured inquiry phases, and they used a mix of process- and product-oriented assessments to monitor progress and judge outcomes. Within these designs, students engaged more actively with mathematical ideas embedded in real-world tasks and demonstrated stronger problem solving, critical thinking, and conceptual understanding alongside gains in collaboration, communication, self-regulation, and confidence.

At the same time, implementation revealed practical constraints. Time demands, uneven participation in heterogeneous groups, and resource limitations were persistent challenges. A balanced assessment approach capturing both the learning process and the quality and accuracy of final products emerged as essential for representing the full scope of student learning in PjBL contexts and for informing timely feedback.

These findings support the feasibility of PjBL as a student-centred, holistic approach consistent with the Kurikulum Merdeka. To broaden and sustain its use, schools and systems should provide targeted professional development on project design and facilitation, ensure access to materials and basic technology, and encourage interdisciplinary projects that connect mathematics with authentic community and sustainability issues.

This study is limited to one school and a bounded period of observation; its claims are therefore context-specific. Future research should include multi-site investigations, longer implementation windows, and mixed-methods designs that incorporate pre- and post-measures of conceptual understanding, transfer, and equity of participation. Such work would clarify the conditions under which PjBL most effectively improves primary mathematics learning in Indonesia and how it can be scaled responsibly.

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